SB761
U7N6
#73-21

INSECT DISEASE REPORT

USDA FOREST SERVICE/NORTHERN REGION

5200

Report No. 73-21 September 1973

SOME OBSERVATIONS ON THE IMPACT OF WESTERN SPRUCE BUDWORM ON THE CLEARWATER NATIONAL FOREST, IDAHO

by

G. C. Franc[1/], P. W. Underwood[2/], and J. E. Dewey[3/]

INTRODUCTION

The current western spruce budworm, *Choristoneura occidentalis* Freeman, outbreak on the Clearwater National Forest was first detected in 1966. Since then, the infestation has increased to epidemic proportions with over 500,000 acres of State, Federal, and private forest land visibly defoliated. In addition, incipient budworm populations are present throughout much of the remaining fir type.

The intensity of the defoliation has fluctuated from year to year and from one area to another; however, in some stands, the damage has been extreme for the duration of the epidemic.

The total impact of the budworm outbreak on the forest environment is subject to speculation. No one can deny the esthetic impact when in late July and early August each year, vast acreages of fir and spruce type turn brown. Cone production is known to have been adversely affected. In areas of repeated defoliation, tree growth almost certainly has been reduced. While no extensive mortality has been observed, some top killing has occurred, primarily in sapling and pole-size trees.

1/ Forester, Clearwater National Forest, Orofino, Idaho.
2/ Forestry Technician, Clearwater National Forest, Orofino, Idaho.
3/ Entomologist, Division of State and Private Forestry, Missoula, Montana.

LIBRARY

OCT 11 1973

ROCKY MOUNTAIN STATION

During the fall of 1971 and 1972, western spruce budworm impact surveys were initiated in four separate areas of infestation on the Clearwater National Forest. The objectives of the impact surveys were:

1. To determine how much volume, by species, is infested using standard tree measurement procedures as applied in timber cruising.

2. To measure intensity of the defoliation based on a visual estimate of the portion of the branches damaged.

3. To determine what portion of the stand has been top killed and how much mortality has occurred.

4. To determine how much of a reduction in growth has occurred in infested stands using growth ring measurements.

METHODS

The four areas selected for the survey are all located on the Clearwater National Forest (Fig. 1).

1. Yoosa Creek.--The 500-acre Yoosa Creek survey area is an uneven aged stand composed of pole and small sawlog size grand fir, subalpine fir, Douglas-fir, and Engelmann spruce. There are also minor volumes of white pine and cedar. The average diameter at breast height (d.b.h.) is 16.7 inches. There is a scattered overstory of mature grand fir. Budworm defoliation was first observed in this area in 1969. Visible defoliation has occurred every year since. The elevation at the Yoosa Creek plot is 4,400 feet.

2. Hungery Creek.--The elevation of the Hungery Creek survey area is 4,600 feet. The study area encompasses 145 acres of pole-size grand fir, subalpine fir, Douglas-fir, and Engelmann spruce. There are a few western larch and lodgepole pine in the stand. The average d.b.h. is 11.3 inches. Budworm defoliation was first detected in Hungery Creek in 1969. This general area has had severe budworm defoliation for several years.

3. Squaw Creek.--The Squaw Creek survey area is 90 acres in size and includes sapling and pole-size grand fir, subalpine fir, and cedar. The average d.b.h. is 15.7 inches. The elevation at the study area is 4,100 feet. Squaw Creek has had the longest record of budworm activity of the four study areas. Defoliation was first detected in 1966.

4. Elk Mountain.--This study area is 160 acres in size and is made up of pole-size Douglas-fir and grand fir with some subalpine fir, lodgepole pine, white pine, western larch, and hemlock. The average d.b.h. is 15.5 inches. The elevation of the area is 4,800 feet. Budworm was first detected in the area in 1970.

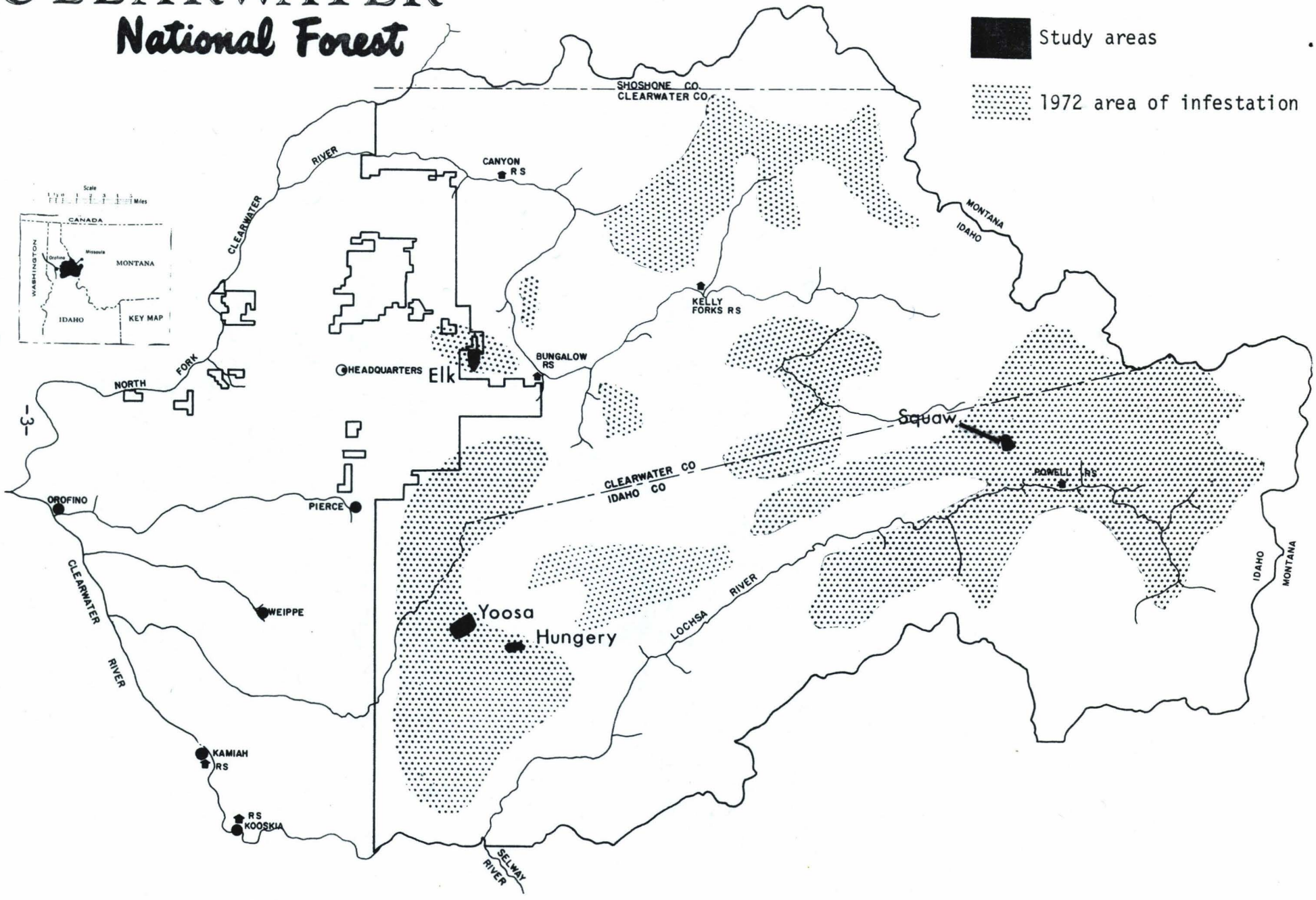

Figure 1.--Study areas for western spruce budworm survey on Clearwater National Forest

Survey Design

The survey area boundaries were delineated on aerial photographs. Survey strips, 10 chains apart, were laid out in a cardinal direction on each photograph. Roads in each of the areas were located on the ground by using a "ready mapper." Strips were run from the base road to the predetermined study area boundary.

Survey plots were established at 5-chain intervals along the survey strips. "In" trees were located using an angle gauge with a 20 basal area factor. Starting points and plot centers were permanently marked so that plots can be re-read in the future. Each tree in each plot is numbered. So that volumes can be computed by automatic data processing, only trees over 5 inches d.b.h. were tallied.

Data Collection

The Region Sale Cruise Tally Sheet (form R1-2430-30) was modified and used to record survey data. Plot numbers, species, d.b.h., and height were recorded in the appropriate columns. Defoliation estimates were recorded in the cut and leave column. The following defoliation codes were used:

0 = Not defoliated.
1 = Light defoliation (0 to 25 percent).
2 = Moderate defoliation (25 to 50 percent).
3 = Heavy defoliation (50 to 75 percent)
4 = Extreme defoliation (75 to 100 percent).
5 = Top killed by budworm.
6 = Tree killed by budworm.

Increment cores were taken on host trees throughout the survey areas. Growth rings prior to and since the infestation were measured in twentieths of an inch. For convenience and because the exact year that the infestation began in each area is not certain, it was assumed that growth has been affected by the budworm only for the past 5 years. The growth for the recent 5-year period (1968-1972) was measured and compared with that of the prior 5 years (1963-1967).

Data Analysis

The cruise sheets were ADP processed. A printout was obtained which listed volumes by species by defoliation class. The increment measurement and growth rates were calculated by hand. The volume lost through growth decline was calculated by ADP by entering the growth measurement in the R-1 Stand Analysis Form (R1-2410-15).

RESULTS AND DISCUSSION

Yoosa Creek

The Yoosa Creek study area was surveyed during the fall of 1971. The findings of that survey have previously been reported (Franc, et al. 1972). There were 442 trees examined on 83 plots in Yoosa Creek. All but 24 were host species. The number of trees by species and damage class are shown in the following table:

Table 1.--Western spruce budworm defoliation, Yoosa Creek, 1971

Species	Total	(0) Not infested	(1) Light	(2) Medium	(3) Heavy	(4) Extreme	(5) Top kill	(6) Mortality
Grand fir	263	0	2	3	48	201	9	0
Engelmann spruce	70	0	0	2	33	35	0	0
Douglas-fir	55	0	1	1	41	12	0	0
Sub-alpine fir	24	0	0	0	4	20	0	0
Mountain hemlock	6	0	0	0	5	1	0	0
Total	418	0	3	6	131	269	9	0

Nonhost trees = 24.

Volumes of green and infested trees in the Yoosa Creek area are shown in table 2:

Table 2.--Volume per acre (BF), Yoosa Creek, 1971

Species	Total volume/acre	Infested volume/acre	Percent
Grand fir	9,403	9,317	99.1
Engelmann spruce	2,252	2,181	96.8
Douglas-fir	1,255	1,239	98.7
Subalpine fir	772	772	100.0
Western redcedar	405	0	0
Western larch	213	0	0
White pine	211	0	0
Total	14,511	13,509	

Of the 9,403 board feet per acre grand fir figure, 123 board feet or 1.3 percent is top killed.

Increment cores were taken from 12 trees at random in the Yoosa Creek area. Growth in twentieths of an inch was measured for the most recent 5 years and for the previous 5 years. The tree-by-tree measurements are listed in the appendix. Since the infestation began, growth has:

1. Declined in seven trees. Average decline = $\frac{6.28}{20}$ of an inch or 41 percent.

2. Increased in four trees. Average increase = 2/20th of an inch or 16 percent.

3. Not changed in one tree.

Based on 12 trees the overall effect in the stand was an average decline of 3/20th of an inch or 22 percent.

Yoosa Creek Re-examination

In 1972 some of the Yoosa Creek plots were re-examined to get an estimate of 1972's defoliation. The following is a comparison of the 2-year findings:

	1971		1972	
	Number	Percent	Number	Percent
Trees examined	418	--	210	--
Not infested (0)	0	0	0	0
Light (1)	3	.70	2	1.0
Moderate (2)	6	1.40	6	2.9
Heavy (3)	131	31.38	60	28.6
Extreme (4)	269	64.40	133	63.3
Top killed (5)	9	2.20	8	3.8
Mortality (6)	0	0	1	.5

The results show no significant change in budworm infestation from 1971 to 1972 with a bulk of the defoliation being heavy or extreme. Some budworm mortality was found in 1972.

Additional increment cores were taken on 52 trees in the Yoosa Creek area during the re-examination in 1972. The growth figures for these trees are listed in the appendix.

Since the infestation began, growth for the 52 trees has:

1. Declined on 45 trees. Average decline = 29/20th of an inch or 35.2 percent.

2. Increased on one tree. Average increase = 1/20th of an inch or 14.3 percent.

3. Remained the same on six trees.

4. Declined overall. Average decline = 2.5/20th of an inch or 31.3 percent.

Hungery Creek

There were 106 trees examined on 29 plots in Hungery Creek. Trees by species were as follows:

Subalpine fir	= 58
Douglas-fir	= 17
Engelmann spruce	= 14
Grand fir	= 10
Western larch	= 5
Lodgepole pine	= 2

Budworm defoliation for the four host species is summarized in the table below:

Table 3.--Western spruce budworm defoliation, Hungery Creek, 1972

Species	No. trees	(0) Not infested	(1) Light	(2) Medium	(3) Heavy	(4) Extreme	(5) Top kill	(6) Dead
Subalpine fir	58	0	3	5	17	30	2	1
Douglas-fir	17	4	0	3	4	5	1	0
Engelmann spruce	14	0	1	3	6	4	0	0
Grand fir	10	0	1	1	2	5	1	0
Total	99	4	5	12	29	44	4	1

Total nonhost species = 7

Volume by species by damage code is listed in table 4.

Increment cores were taken and measured from 27 trees in the Hungery Creek area. The growth measurements are shown in Appendix A.

Table 4.--Volume per acre (BF), Hungery Creek, 1972

Species	Total volume	(0) Not infested	(1) Light	(2) Medium	(3) Heavy	(4) Extreme	(5) Top kill	(6) Mortality
Subalpine fir	3,400	0	22	300	1,118	1,716	232	12
Douglas-fir	1,046	0	0	332	376	247	91	0
Engelmann spruce	1,248	0	7	320	787	134	0	0
Grand fir	528	0	0	159	19	315	35	0
Western larch	553	553	0	0	0	0	0	0
Lodgepole pine	215	215	0	0	0	0	0	0
Total	6,990	768	29	1,111	2,300	2,412	358	12

Since the infestation began, growth has:

1. Declined in 20 trees. Average decline = 3.2/20th of an inch per tree or 27.1 percent.

2. Increased in three trees. Average increase = 1/20th of an inch per tree or 13.6 percent.

3. Not changed on four trees.

4. Declined overall. Average decline = 2.3/20th of an inch per tree or 21.9 percent.

Squaw Creek

There were 45 trees examined on 18 plots in Squaw Creek. Trees by species were as follows:

Grand fir	= 16
Spruce	= 13
Subalpine fir	= 6
Douglas-fir	= 3
Cedar	= 7

Budworm defoliation for the four host species is shown in Table 5.

Table 5.--Western spruce budworm defoliation, Squaw Creek, 1972

Species	Total	(0) Not infested	(1) Light	(2) Medium	(3) Heavy	(4) Extreme	(5) Top kill	(6) Mortality
Grand fir	16	0	2	4	5	5	0	0
Engelmann spruce	13	0	0	4	5	3	1	0
Subalpine fir	6	0	0	0	0	4	2	0
Douglas-fir	3	0	0	2	1	0	0	0
Total	38	0	2	10	11	12	3	0

Nonhost species = 7

Volumes by species by damage code are shown in the following table:

Table 6.--Volume per acre (BF), Squaw Creek, 1972

Species	Total	(0) Not infested	(1) Light	(2) Medium	(3) Heavy	(4) Extreme	(5) Top kill	(6) Mortality
Grand fir	1,891	0	264	563	536	528	0	0
Engelmann spruce	2,959	0	0	1,117	782	769	291	0
Subalpine fir	831	0	0	0	0	588	243	0
Douglas-fir	546	0	0	362	184	0	0	0
Cedar	583	583	0	0	0	0	0	0
Total	6,810	583	264	2,042	1,502	1,885	534	0

Increment cores were taken from nine trees in the Squaw Creek survey area. Growth measurements are tabulated in Appendix B.

Since the budworm epidemic began, growth has declined on all nine trees. The average decline per tree is 5/20th of an inch or 44 percent.

Elk Mountain

There were 116 trees on 32 plots in the Elk Mountain study area. Trees by species were as follows:

Douglas-fir	71
Grand fir	27
Spruce	3
Subalpine fir	1
Nonhost	44

Nonhost species included hemlock, white pine, lodgepole pine, and western larch. Although mountain hemlock has been found budworm infested on the Forest, it was considered a nonhost species for this study because none was found infested on Elk Mountain.

Defoliation damage for the four host species is shown in the following table:

Table 7.--Western spruce budworm defoliation, Elk Mountain, 1972

Species	No. trees	(0) Not infested	(1) Light	(2) Medium	(3) Heavy	(4) Extreme	(5) Top kill	(6) Mortality
Douglas-fir	41	0	9	17	10	4	1	0
Grand fir	27	0	0	1	6	19	1	0
Engelmann spruce	3	0	1	0	2	0	0	0
Subalpine fir	1	0	0	0	1	0	0	0
Total	72	0	10	18	19	23	2	0

Total nonhost species = 44.

Volumes by species by damage code are shown in table 8.

Increment cores were taken on 10 host trees in the Elk Mountain study area. The growth measurements for these 10 trees are listed in Appendix B.

All host trees measured declined in growth since the budworm infestation began. The average decline was 2.2/20th of an inch per tree or 20.4 percent.

Table 8.--Volume per acre (BF), Elk Mountain, 1972

Species	Total	(0) Not infested	(1) Light	(2) Medium	(3) Heavy	(4) Extreme	(5) Top kill	(6) Mortality
Douglas-fir	2,269	0	412	1,098	505	180	74	0
Grand fir	1,576	0	0	0	273	1,259	44	0
Engelmann spruce	181	0	60	0	121	0	0	0
Subalpine fir	93	0	0	0	93	0	0	0
Lodgepole pine	976	976	0	0	0	0	0	0
White pine	407	407	0	0	0	0	0	0
Western larch	229	229	0	0	0	0	0	0
Mountain hemlock	179	179	0	0	0	0	0	0
Total	5,910	1,791	472	1,098	992	1,439	118	0

Combined Results

There was a total of 627 host trees examined in the four impact survey areas. The number of trees by area in each damage category is shown in table 9.

The four survey areas comprise 895 acres. The combined volumes by species for the areas are shown in table 10.

The average volume per acre on the 895 acres is 10,755 board feet.

Host species make up 91 percent of the stand by volume:

1. Only 1 percent of the host volume is uninfested.
2. By volume, 2.1 percent is top killed.
3. Mortality, by volume, is less than 0.0002 percent.

Table 9.--Host trees examined by damage class

Area	Total trees	(0) Uninfested	(1) Light	(2) Medium	(3) Heavy	(4) Extreme	(5) Top kill	(6) Mortality
Yoosa Creek	418	0	3	6	131	269	9	0
Hungery Cr.	99	4	5	12	29	44	4	1
Squaw Creek	38	0	2	10	11	12	3	0
Elk Mtn.	72	0	10	18	19	23	2	0
Total	627	4	20	46	190	348	18	1
Percent of total		.6	3.2	7.3	30.3	55.5	2.9	.2

Table 10.--Board foot volumes, by species, by area

Species	Total volume	Green volume	Light to extreme defoliation	Infested volume top killed	Mortality
*Grand fir	5,202,147	42,919	5,085,806	73,422	0
*Engelmann spruce	1,414,878	35,743	1,352,965	26,170	0
*Douglas-fir	1,174,667	7,822	1,141,900	24,945	0
*Subalpine fir	968,577	0	911,392	55,509	1,676
Western redcedar	255,116	255,116	0	0	0
Western larch	223,237	223,237	0	0	0
Lodgepole pine	187,315	187,315	0	0	0
White pine	170,769	170,769	0	0	0
Mountain hemlock	28,399	28,399	0	0	0
Total	9,625,105	951,320	8,492,063	180,046	1,676
*Host total	8,760,269	86,484	8,492,063	180,046	1,676

Top killing and mortality occur more rapidly in small pole and sapling size trees. In Yoosa Creek where a wide range of size classes are present, some small, suppressed grand fir were found to be free of defoliation, apparently escaping attack by virtue of the shielding provided by the stand canopy; however, in other areas, understory trees are often severely damaged.

Growth measurements were taken on 110 host trees. Since the western budworm epidemic began, growth has:

1. Declined on 91 trees. The average decline is 3.7/20th of an inch per tree, or 33.0 percent.

2. Increased on eight trees. The average increase is 1.5/20th of an inch per tree or 15.4 percent.

3. Remained unchanged on 11 trees.

4. Declined overall. The average decline is 2.7/20th of an inch per tree or 27.5 percent,

Nonhost Growth

Increment cores were taken from 55 nonhost trees in or adjacent to the survey areas. Growth before and after the arrival of the budworm was measured in twentieths of an inch just as it was for the four host species. This information was used to determine what the growth in nonhost trees was doing during the same period as compared to the decline in host trees. The individual tree-by-tree measurements can be found in Appendix B.

On the 55 nonhost trees, growth had:

1. Increased on 17 trees. The average increase was 1.5/20th of an inch per tree or 19.0 percent.

2. Remained unchanged on 17 trees.

3. Declined on 21 trees. The average decline was 1.6/20th of an inch per tree or 15.3 percent.

4. Declined overall. The average decline was .1/20th of an inch per tree or 1.8 percent.

The four survey areas represent different periods of infestation and a comparison was made of growth decline versus duration of infestation. The findings are summarized in the following table:

Table 11.--Comparison of growth decline versus duration of infestation

Area	Year spruce budworm detected	Number of trees sampled	Year	Duration (years)	Percent loss
Yoosa Creek	1969	12	1971	3	22
Elk Mtn.	1970	10	1972	3	20
Yoosa Creek	1969	52	1972	4	31
Hungery Cr.	1969	27	1972	4	22
Squaw Creek	1966	9	1972	7	44

As might be expected, there is a very strong relationship between duration of infestation and growth loss with growth loss increasing drastically as the period of infestation increases.

A comparison was made of growth impact by species. For this purpose, the growth figures for all four survey areas were combined by species. The following table summarizes the findings:

Table 12.--Growth impact by species

Species	Number of trees sampled	Rate of decline (percent)
Grand fir	54	31.5
Douglas-fir	18	26.9
Subalpine fir	30	23.2
Engelmann spruce	8	15.4

Grand fir, Douglas-fir, and spruce performed as would be expected since grand fir generally suffers more damage than the others, and spruce, on the other hand, exhibits less damage. Subalpine fir, however, fared better than expected, since it is often more heavily defoliated than the other three species. Of the 30 subalpine fir bored, four remained unchanged in growth and four actually increased in growth. These trees were generally more lightly infested.

Exactly how much of the 27.5 percent decline in growth in the host species can be attributed to the western spruce budworm is not known. If, however, the average decline of 1.8 percent exhibited by nonhost trees during the same period is representative of what the host tree would have experienced without the added impact of the budworm, then it would appear that the budworm caused a growth decline of 25.7 percent.

An ADP analysis of the growth rings of the 100 trees bored showed that the annual increment for the last 10 years in the survey areas would have been 295 board feet per acre had not the budworm epidemic occurred. The actual average annual growth for the last 10 years with the effect of the budworm is 266 board feet per acre. This represents a loss of 259,550 board feet in growth on the 895 acres surveyed. The average stumpage rate for the Clearwater National Forest for the first half of fiscal year 1973 was $26.09 per M. Using this figure as a factor the total value of the growth loss can be estimated at $6,771.66 for the area surveyed. If the 895 acres surveyed are representative of the 500,000 acres of infestation in the Clearwater National Forest, then the total growth loss for the past 10 years attributed to budworm would be 145 million board feet with a value of $3,783,050.

The procedure of proportioning the measured loss on 895 acres over the entire 500,000-acre zone of infestation may not be entirely valid, and the following factors must be taken into consideration:

1. The duration and intensity of the infestation varies within the zone of infestation.

2. There are a variety of timber types and age classes present in the zone of infestation.

3. The zone of infestation is broad and includes some nonforest type.

On the other hand:

1. The zone of infestation represents that portion of the forest where visible budworm defoliation has occurred. Incipient budworm can be found in fir stands outside the zone of infestation. Some growth loss may be occurring in stands outside of the delineated zone of infestation.

2. The four survey areas differ in composition, age, and density and each has a slightly different infestation history, so that at least four of the many variables in the zone of infestation are sampled.

The average stumpage rate of $26.09 was taken from the first half of F.Y. 1973 cutting report and represents the average price of all species cut during that period. A check was made of the average selling price of the host species as compared to the average selling price of all species during the same period. The average selling price for the host species was within a few cents of the average of all species, and in fact, was the higher of the two for this period. Thus, the $26.09 per board foot cutting report stumpage figure is a conservative value to apply to the growth loss at this time.

Taking all things into consideration, it seems certain that, in terms of growth loss, the budworm epidemic has cost the Clearwater National Forest in excess of $3 million. The loss continues to accrue each year that the epidemic continues.

CONCLUSIONS

Within the 500,000-acre zone of infestation on the Clearwater National Forest, host species are almost 100 percent infested by the western budworm. Most of the damage is rated as heavy or extreme with 50 to 100 percent of the new growth on the branches defoliated. Even so, top kill and mortality, at least in pole and sawlog size trees, is light. Growth loss is very significant. Growth has declined by about one-fourth on host trees in the areas surveyed. In terms of dollars lost, the decline in growth may very well be the budworm's area of greatest impact. Still needing study is the impact the budworm epidemic has had on natural and artificial regeneration and on the production of cones.

REFERENCE CITED

Franc, G. C., P. W. Underwood, and J. E. Dewey. A western spruce budworm impact survey on the Clearwater NF, report I-72-4, July 1972. USDA Forest Service, Div. State and Priv. Forestry, Missoula, MT.

APPENDIX A. TREE-BY-TREE GROWTH MEASUREMENTS - HOST SPECIES

Tree No.	Species	D.b.h.	Growth recent 5 years	Previous 5 years	Difference
		YOOSA CREEK - 1971			
1	Douglas-fir	20	15/20	12/20	+ 3/20
2	Grand fir	26	9/20	20/20	- 11/20
3	Grand fir	10	21/20	20/20	+ 1/20
4	Subalpine fir	24	7/20	17/20	- 10/20
5	Grand fir	20	6/20	8/20	- 2/20
6	Grand fir	18	9/20	9/20	0
7	Subalpine fir	22	6/20	14/20	- 8/20
8	Subalpine fir	24	13/20	10/20	+ 3/20
9	Grand fir	16	16/20	26/20	- 10/20
10	Douglas-fir	15	10/20	12/20	- 2/20
11	Engelmann spruce	27	8/20	7/20	+ 1/20
12	Grand fir	9	10/20	11/20	- 1/20
Total			130/20	166/20	- 36/20
Subtotal growth decline			64/20	108/20	- 44/20
Subtotal growth increase			57/20	49/20	+ 8/20
		YOOSA CREEK - 1972			
1	Grand fir	16	4/20	7/20	- 3/20
2	Grand fir	27	3/20	4/20	- 1/20
3	Grand fir	16	6/20	7/20	- 1/20
4	Grand fir	30	4/20	6/20	- 2/20
5	Grand fir	28	5/20	9/20	- 4/20
6	Grand fir	12	1/20	2/20	- 1/20
7	Engelmann spruce	24	2/20	2/20	0
8	Grand fir	32	3/20	3/20	0
9	Grand fir	31	3/20	3/20	0
10	Grand fir	15	2/20	3/20	- 1/20
11	Grand fir	11	8/20	12/20	- 4/20
12	Douglas-fir	15	7/20	8/20	- 1/20
13	Douglas-fir	15	4/20	6/20	- 2/20
14	Grand fir	9	1/20	2/20	- 1/20
15	Grand fir	33	3/20	3/20	0
16	Grand fir	7	4/20	5/20	- 1/20
17	Grand fir	26	15/20	20/20	- 5/20
18	Douglas-fir	20	2/20	9/20	- 7/20
19	Douglas-fir	19	8/20	11/20	- 3/20
20	Grand fir	13	16/20	16/20	0
21	Grand fir	13	8/20	12/20	- 4/20
22	Grand fir	16	2/20	5/20	- 3/20
23	Grand fir	11	1/20	3/20	- 2/20

APPENDIX A. TREE-BY-TREE GROWTH MEASUREMENTS - HOST SPECIES

Tree No.	Species	D.b.h.	Growth recent 5 years	Previous 5 years	Difference
		YOOSA CREEK - 1972, con.			
24	Grand fir	31	4/20	8/20	- 4/20
25	Subalpine fir	10	7/20	8/20	- 1/20
26	Grand fir	24	6/20	10/20	- 4/20
27	Grand fir	23	5/20	10/20	- 5/20
28	Grand fir	7	1/20	2/20	- 1/20
29	Grand fir	35	5/20	7/20	- 2/20
30	Grand fir	16	3/20	7/20	- 4/20
31	Grand fir	13	6/20	11/20	- 5/20
32	Grand fir	14	12/20	17/20	- 5/20
33	Douglas-fir	10	6/20	7/20	- 1/20
34	Douglas-fir	14	6/20	9/20	- 3/20
35	Engelmann spruce	13	5/20	8/20	- 3/20
36	Grand fir	17	7/20	11/20	- 4/20
37	Grand fir	12	6/20	12/20	- 6/20
38	Grand fir	7	3/20	6/20	- 3/20
39	Grand fir	26	11/20	17/20	- 6/20
40	Grand fir	13	4/20	8/20	- 4/20
41	Grand fir	8	2/20	3/20	- 1/20
42	Engelmann spruce	18	10/20	10/20	0
43	Grand fir	8	2/20	4/20	- 2/20
44	Grand fir	13	7/20	10/20	- 3/20
45	Grand fir	20	9/20	12/20	- 3/20
46	Grand fir	12	7/20	12/20	- 5/20
47	Douglas-fir	20	9/20	12/20	- 3/20
48	Subalpine fir	24	4/20	5/20	- 1/20
49	Grand fir	18	8/20	7/20	+ 1/20
50	Grand fir	25	6/20	9/20	- 3/20
51	Grand fir	16	5/20	6/20	- 1/20
52	Grand fir	20	10/20	13/20	- 3/20
Total			288/20	419/20	-131/20
Subtotal growth decline			243/20	375/20	-132/20
Subtotal growth increase			8/20	7/20	+ 1/20
		HUNGERY CREEK - 1972			
1	Subalpine fir	10	7/20	6/20	+ 1/20
2	Subalpine fir	8	8/20	7/20	+ 1/20
3	Subalpine fir	7	5/20	5/20	0
4	Subalpine fir	10	7/20	8/20	- 1/20
5	Subalpine fir	24	9/20	9/20	0
6	Subalpine fir	21	5/20	5/20	0

APPENDIX A. TREE-BY-TREE GROWTH MEASUREMENTS - HOST SPECIES

Tree No.	Species	D.b.h.	Growth recent 5 years	Previous 5 years	Difference
		HUNGERY CREEK - 1972, con.			
7	Subalpine fir	9	9/20	12/20	- 3/20
8	Subalpine fir	7	9/20	12/20	- 3/20
9	Subalpine fir	7	8/20	10/20	- 2/20
10	Engelmann spruce	24	17/20	19/20	- 2/20
11	Subalpine fir	13	11/20	14/20	- 3/20
12	Subalpine fir	24	4/20	7/20	- 3/20
13	Douglas-fir	7	9/20	16/20	- 7/20
14	Subalpine fir	11	5/20	12/20	- 7/20
15	Douglas-fir	9	18/20	25/20	- 7/20
16	Subalpine fir	13	9/20	12/20	- 3/20
17	Subalpine fir	16	10/20	13/20	- 3/20
18	Engelmann spruce	15	11/20	15/20	- 4/20
19	Subalpine fir	9	8/20	10/20	- 2/20
20	Subalpine fir	12	7/20	9/20	- 2/20
21	Subalpine fir	11	5/20	6/20	- 1/20
22	Subalpine fir	9	6/20	8/20	- 2/20
23	Subalpine fir	13	4/20	7/20	- 3/20
24	Subalpine fir	13	6/20	10/20	- 4/20
25	Subalpine fir	13	2/20	2/20	0
26	Subalpine fir	11	10/20	9/20	+ 1/20
27	Subalpine fir	15	9/20	11/20	- 2/20
Total			218/20	279/20	- 61/20
Subtotal growth decline			172/20	236/20	- 64/20
Subtotal growth increase			25/20	22/20	+ 3/20
		SQUAW CREEK - 1972			
1	Grand fir	27	5/20	23/20	- 18/20
2	Douglas-fir	19	6/20	9/20	- 3/20
3	Douglas-fir	29	4/20	7/20	- 3/20
4	Grand fir	4	5/20	9/20	- 4/20
5	Grand fir	6	8/20	13/20	- 5/20
6	Grand fir	7	10/20	13/20	- 3/20
7	Subalpine fir	9	6/20	10/20	- 4/20
8	Subalpine fir	15	2/20	3/20	- 1/20
9	Douglas-fir	14	11/20	15/20	- 4/20
Total			57/20	102/20	- 45/20

APPENDIX A. TREE-BY-TREE GROWTH MEASUREMENTS - HOST SPECIES

Tree No.	Species	D.b.h.	Growth recent 5 years	Previous 5 years	Difference
		ELK MOUNTAIN - 1972			
1	Douglas-fir	17	7/20	9/20	- 2/20
2	Douglas-fir	26	3/20	4/20	- 1/20
3	Grand fir	14	10/20	12/20	- 2/20
4	Grand fir	19	12/20	13/20	- 1/20
5	Grand fir	18	15/20	21/20	- 6/20
6	Grand fir	23	15/20	17/20	- 2/20
7	Douglas-fir	12	5/20	6/20	- 1/20
8	Engelmann spruce	9	7/20	8/20	- 1/20
9	Engelmann spruce	10	6/20	9/20	- 3/20
10	Douglas-fir	33	6/20	9/20	- 3/20
Total			86/20	108/20	- 22/20

APPENDIX B. TREE-BY-TREE GROWTH MEASUREMENTS - NONHOST SPECIES

Species	D.b.h.	Growth recent 5 years	Previous 5 years	Difference
		YOOSA CREEK		
Lodgepole pine	11	3/20	3/20	0
White pine	17	6/20	7/20	- 1/20
Western redcedar	11	10/20	11/20	- 1/20
Lodgepole pine	15	5/20	5/20	0
White pine	16	14/20	15/20	- 1/20
White pine	16	8/20	9/20	- 1/20
White pine	18	3/20	3/20	0
White pine	16	9/20	9/20	0
Lodgepole pine	15	4/20	4/20	0
Western larch	20	1/20	1/20	0
White pine	23	9/20	11/20	- 2/20
Lodgepole pine	14	5/20	7/20	- 2/20
White pine	23	12/20	9/20	+ 3/20
Western redcedar	10	5/20	4/20	+ 1/20
Western redcedar	15	13/20	13/20	0
White pine	21	3/20	3/20	0
White pine	17	16/20	17/20	- 1/20
Western redcedar	15	11/20	9/20	+ 2/20
Western larch	13	4/20	5/20	- 1/20
Western larch	32	3/20	2/20	+ 1/20
Total		144/20	147/20	- 3/20
Subtotal growth decline		72/20	82/20	- 10/20
Subtotal growth increase		31/20	24/20	+ 7/20
		ELK MOUNTAIN		
White pine	11	6/20	5/20	+ 1/20
White pine	27	16/20	15/20	+ 1/20
White pine	12	4/20	4/20	0
White pine	15	7/20	8/20	- 1/20
White pine	12	9/20	9/20	0
White pine	14	13/20	14/20	- 1/20
Western larch	11	8/20	10/20	- 2/20
Western larch	11	5/20	6/20	- 1/20
Western larch	9	5/20	5/20	0
Western redcedar	11	13/20	11/20	+ 2/20
Western redcedar	23	13/20	13/20	0
Western redcedar	12	8/20	7/20	+ 1/20
Lodgepole pine	13	5/20	5/20	0
Lodgepole pine	15	7/20	6/20	+ 1/20
Mountain hemlock	14	5/20	7/20	- 2/20
Total		124/20	125/20	- 1/20
Subtotal growth decline		38/20	45/20	- 7/20
Subtotal growth increase		88/20	44/20	+ 6/20

APPENDIX B. TREE-BY-TREE GROWTH MEASUREMENTS - NONHOST SPECIES

Species	D.b.h.	Growth recent 5 years	Previous 5 years	Difference
		SQUAW CREEK		
Western redcedar	--	18/20	15/20	+ 3/20
Western redcedar	--	11/20	9/20	+ 2/20
White pine	--	9/20	7/20	+ 2/20
Western larch	--	2/20	2/20	0
White pine	--	5/20	4/20	+ 1/20
White pine	--	7/20	10/20	- 3/20
White pine	--	5/20	7/20	- 2/20
White pine	--	4/20	4/20	0
White pine	--	2/20	2/20	0
White pine	--	2/20	4/20	- 2/20
White pine	--	5/20	6/20	- 1/20
Western larch	--	2/20	3/20	- 1/20
Western larch	--	2/20	2/20	0
Western larch	--	4/20	3/20	+ 1/20
Western redcedar	--	14/20	13/20	+ 1/20
Western redcedar	--	13/20	11/20	+ 2/20
Western redcedar	--	21/20	25/20	- 4/20
Western redcedar	--	14/20	16/20	- 2/20
Western redcedar	--	22/20	24/20	- 2/20
Western redcedar	--	8/20	7/20	+ 1/20
Total		170/20	170/20	- 4/20
Subtotal growth decline		78/20	95/20	- 17/20
Subtotal growth increase		82/20	69/20	+ 13/20